Reilly, J. J., Hughes, A. R., Janssen, X., Hesketh, K., Livingstone, S., Hill, C., Kipping, R., Draper, C. E., Okely, A. D., & Martin, A. (2020). GRADE ADOLOPMENT Process to Develop 24-Hour Movement Behavior Recommendations and Physical Activity Guidelines for the Under 5s in the UK, 2019. *Journal of Physical Activity and Health*, *17*(1), 101-108. https://doi.org/10.1123/jpah.2019-0139

GRADE ADOLOPMENT Process to Develop 24-Hour Movement Behavior Recommendations and Physical Activity Guidelines for the Under 5s in the UK, 2019

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Running Title: UK Physical Activity Guidelines for the Under 5s

Conflicts of Interest: None to declare

Word Count: 4928

Keywords: physical activity; sedentary behaviour; sleep; infants; toddlers; children

ABSTRACT

Background: Physical activity guideline developers are faced with demands to produce guidelines quickly and at low cost. This paper summarises a new, efficient, approach taken to develop UK Chief Medical Officers' (CMOs) Guidelines for the Under 5s, 2019.

Methods: The Grading of Recommendations Assessment, Development and Evaluation (GRADE) Adaptation, Adoption, De Novo Development (ADOLOPMENT) approach was used, based on 24-hour movement behavior guidelines from Canada and Australia in 2017, with a systematic review update in 2018. Draft recommendations were based on (a) the influence of time spent asleep, sedentary, and in physically activity on 10 health outcomes and (b) the influence of PA and sedentary behaviour (including screen time) on sleep outcomes (e.g. duration, latency).

Results: There was consistent evidence of links between the 24-hour movement behaviors and all outcomes, and a high degree of UK stakeholder support for all draft recommendations. UK Guidelines for the Under 5s will be published in 2019 with new guidance on infant tummy time and moderate-to-vigorous-intensity physical activity in pre-schoolers, but draft recommendations on sleep and screen time were not accepted by the CMOs.

Conclusions: This was the first time that the GRADE ADOLOPMENT process has been used in Europe to develop physical activity guidelines. It permitted a rapid and inexpensive production of the UK Physical Activity Guidelines for the Under 5s.

INTRODUCTION

The UK first published guidance on physical activity for the early years (birth-school-entry) in 2011[1]. This 2011 'Start Active, Stay Active' guidance was based largely on expert opinion, and limited to only a single quantitative recommendation, that 3-4 year olds should spend a minimum of 180 minutes in physical activity every day[1]. By 2018, there was a larger body of evidence on the benefits of physical activity for growth and development in the Under 5s than was available to inform 'Start Active, Stay Active'[2-7]. There has also been a substantial shift in the way physical activity is understood by academics in this field- it is no longer seen in isolation from the other '24-hour movement behaviors[2,8]' (sedentary behaviour including screen time, and sleep, and arguably time spent standing). In a fixed 24-hour day the time spent in one of these behaviors must inevitably influence the others, and by the time children go to school physical activity declines with increasing age, and is displaced by time spent sedentary[9-11]. Sedentary time continues to increase with age, producing further declines in physical activity. Although sleep requirements naturally decrease with age, sleep duration is also affected by time spent in physical activity and sedentary behavior[12,13]. These movement behaviors each influence health and development, and the combination of behaviors also matters[2,7,8], so that evidence-based recommendations for the full 24-hour period can now be made.

The WHO Ending Childhood Obesity (ECHO) Reports[14,15] concluded that improving 24-hour movement behaviors in the early years was central to the global prevention and treatment of obesity and related non-communicable diseases (NCDs). The first evidence-based '24-Hour Movement Behaviour Guidelines' for the early years (prior to school entry) were published in 2017 in Canada, Australia, and New Zealand[2,3] . Evidence-based national guidelines on 24-hour movement behaviors were released in 2018 in South Africa[16], and international guidance on physical activity, sedentary and sleep behaviors from the World Health Organisation (WHO) was published in 2019[17]. The process of updating UK 2011 guidance started at the end of 2017.

The aim of this manuscript is to describe the guideline development process for the Under 5s in the UK, highlighting both the strengths and weaknesses of this process, and the evidence base used to develop the recommendations. The UK guideline development process was based on the principle that the most recent and relevant guidelines should be adapted so that new UK guidelines could be developed relatively quickly and at low cost.

METHODS

The process of updating the UK Physical Activity Guidelines 2011-'Start Active, Stay Active'- was conducted in three phases. Phase 1 saw an initial web consultation to assess support for the guideline update and to take suggestions as to format and content; the construction of Expert Working Groups (for the Under 5s; for school-age children and adolescents; for adults; for older adults; for sedentary behavior from age 5 to old age; for guideline communication and implementation); the selection of international experts for each working group; formal evidence review and synthesis during 2018, and a website for national consultations on the new UK CMOs (for Scotland, Northern Ireland, Wales and England) guidelines (http://www.bristol.ac.uk/sps/research/projects/current/physical-activity/). In Phase 2, draft recommendations were developed and circulated to participants attending two scientific consensus meetings in Edinburgh and London, during June and July of 2018, respectively. Draft recommendations were revised following feedback from the scientific consensus meetings, and responses to end-user or stakeholder feedback were provided. Phase 3 included further national online consultation on the draft recommendations, and a final round of review and revision in response to that consultation. The expert working group concluded their work by producing a technical report with recommendations for the content and wording of new guidelines which were submitted to the CMOs of Scotland, England, Wales, and Northern Ireland in November 2018. The expert working group was responsible for recommending what the guidelines should contain and how they should be worded. In the UK the guideline development process is conducted under the auspices of the Health Departments and so they alone were responsible for accepting or rejecting the draft recommendations. A UK CMOs

Guidelines Writing Group supported the production of a final CMO Physical Activity Guidelines Report in 2019.

Initial Scoping and Planning of the Work for the Under 5s

Phase 1 began with the formation of the Expert Working Group for the Under 5s at the end of 2017, from a combination of open advertising/competition, and invitation. The aim was to have group members, including early and mid-career academics, with the following characteristics: experience of the UK Start Active Stay Active process 2009-2011; content expertise in the age groups for all three behaviors (sleep, sedentary behavior, physical activity); expertise in guideline development methodology; or experience of other ongoing/recently completed Early Years physical activity guidelines internationally.

The Expert Working Group received feedback from a UK-wide online consultation (the first of three stages of consultation required in the UK process) in January 2018. This initial consultation supported a guideline update using the concept of 24-hour movement behaviors, emphasised the value of harmonisation with international guidelines (particularly from Canada and Australia), and recommended publication of a summary of the process in the peer-reviewed literature.

The Under 5s Expert Working Group outlined a schedule of approximately monthly online meetings starting in January 2018, identified tasks and milestones required if the project was to be completed on time, and formed sub-groups for specific tasks. The Expert Working Group was represented on the wider Chairs Panel of UK Expert Working Groups (led by the University of Bristol) which also had monthly online meetings to guide and co-ordinate the work of the UK Expert Working Groups.

A number of practical and scientific considerations underpinned the guideline development work described in this manuscript. First, in common with the other Expert Working Groups, the work of the Under 5s Expert Working Group was based on the best (most recent, relevant, evidence-based) existing guidelines internationally. Thus, the starting point for the UK guideline update for the Under 5s was the 24-hour movement behavior approach[2,3], and this was approved in principle by the UK CMOs in early 2018. Second, and also in common with the other Expert Working Groups, a default position was agreed by the authors (supported by national consultations) that the UK draft recommendations should be as consistent as possible with the best available international guidance, departing from it only where there was new evidence and/or compelling argument for doing so[2,3].

Implementing these early working group decisions was possible with the support of the other national and international guideline development groups. Most notably, our work in 2018 was informed by a) the WHO guideline development group (up to February 2018), and b) by the inclusion of international experts who led the South African and Australian processes in the UK Expert Working Group. Implementing these early decisions was also possible because of Grading of Recommendations Assessment, Development and Evaluation (GRADE) Adaptation, Adoption, De Novo Development (ADOLOPMENT) approach[18]. The GRADE ADOLOPMENT approach is an evidence-based, and efficient (relatively quick and low cost) process for developing guidelines by adapting/adopting/developing existing guidelines. Recently, the Australian 24-Hour Movement Behaviour Guidelines were developed by the process of ADOLOPMENT of the Canadian Guidelines[3]. The UK Under 5s Expert Working Groups therefore used the GRADE ADOLOPEMENT approach to develop the new draft recommendations.

The GRADE ADOLOPMENT Process

The GRADE ADOLOPMENT process involves a series of steps leading to adoption, adaptation, and/or de novo development of an existing guideline. The first task of the Expert Working Group, guided by

our GRADE methodologist (AM) was to translate these steps into a series of tasks, summarised in brief here, and in **Table 1.**

It is worth noting that the process of updating the "Start Active Stay Active" 2011 guideline for the Under 5s in the UK followed GRADE ADOLOPMENT, but in the UK different individuals and groups are responsible for different stages of the guideline development process. The Expert Working Group was responsible for making draft scientific recommendations by the end of May 2018, for consultation (online and via two Scientific Consensus Meetings attended mainly by academics and policymakers) in June and July 2018. The Expert Working Group then responded to all points raised in this second consultation process and produced revised draft recommendations taking account of scientific review and stakeholder feedback. Beyond this point, the final guideline content, wording, launch, and implementation was the responsibility of the four UK CMOs as noted above. The CMOs were therefore responsible not only for deciding on whether the draft recommendations would become guidelines, but also for some tasks which are essential to the GRADE-ADOLOPMENT process, including: the development of strategies and materials for dissemination of the new guidelines; consideration of issues such as equity of the new guidelines (the extent to which new guidelines might disadvantage groups defined by age, gender, ethnicity, or socio-economic status); costs of disseminating and implementing the new guidelines, and a third and final stage of consultation on the final guidelines (with wider lay/public stakeholders). This manuscript focuses on the Expert Working Group responsibilities, up to the point where final draft recommendations were made as to the content of the guidelines to the four UK CMOs in November 2018, after all feedback from stakeholders up to that point had been considered.

Some of the tasks undertaken by the Expert Working Group were essential but relatively simple (e.g. establishing a shared folder for access to files; declaration of competing interests) while others required more discussion and judgement. The first major task was to agree on the source guideline(s)[3,18] on which the new UK guideline should be based (Table 1, item 2). A search for recent relevant guidelines had

been carried out by the Bristol Co-ordinating Centre in 2017 and this did not identify any recent relevant guidelines for the early years. We updated the Bristol search with knowledge of the Canadian and Australian Early Years Guidelines[2,3] (published 20th November 2017) and the ongoing South African and WHO Guidelines (which also had the intention to use GRADE-ADOLOPMENT based on the Canadian and Australian Guidelines). In addition, the US Guideline Development Process Evidence Synthesis became available in March 2018, though the US guideline was not published until November 2018. The comparison of candidate guidelines against criteria for selecting a source guideline is summarised in **Table 2,** and supported our judgement that our source guideline would be the Canadian 24-Hour Movement Behaviour Guidelines for the Early Years (https://csepguidelines.ca/early-years-0-4/)[2]. The Australian 2017 Guidelines were largely adopted from the Canadian guidelines[3].

The second task (**Table 1**, item 3) was to agree that the PICOs (Population, Intervention/Exposure, Comparator, Outcomes) which had been used in the Canadian/Australian and WHO systematic review/evidence synthesis (which was shared by WHO in February 2018) were appropriate to our UK guideline update. The PICOs were agreed by the Expert Working Group and are summarised in **Table 3.**

The next task (Table 1, items 4, 7-9) was to compile GRADE Summary of Findings Tables for each of the target behaviors (time spent asleep, in sedentary behavior including screen time, and in physical activity). As recommended by GRADE, separate tables for different exposures of the 24-hour movement behaviors were generated from the original versions of the GRADE tables shared with us. **Table 4** gives an overview of the type and number of exposures for the three 24-hour movement behaviors, indicating that in the literature each 24-hour movement behavior is assessed and reported in a number of ways. For example, 13 exposures for physical activity were identified, three exposures for sedentary time, and seven exposures for sleep. The quality of evidence was then assessed for each of the three age groups (infants, up to age 1.0 year; toddlers 1.0 to 2.9 years; pre-schoolers 3.0 to 4.9 years)

separately within a particular exposure. Separating the evidence for each exposure-outcome relationship, and also presenting it separately by the three age groups provided a much better understanding of the quantity, quality, and consistency of evidence of the associations with health of 24-hour movement behaviors in the early years than had been available previously. This detailed consideration also made it easier to both draft and explain the recommendations, for example it was possible to make explicit reference to time spent in physically active play in the draft recommendations (rather than just in future public health 'messaging' of the guidelines) because physically active play was an exposure identified in the revised GRADE tables.

The GRADE ADOLOPMENT process requires a consensus on the balance of adoption, adaptation, and de novo creation of recommendations[3,18]. The de novo creation of a recommendation in the UK 2018 Under 5s guideline development process arose from the desire of the UK Expert Working Group to go beyond the work done by guideline development groups in Canada, Australia, South Africa, and the WHO in order to provide new guidance on sleep as an *outcome* with physical activity and sedentary behavior as the exposure variables (**Table 1**; items 6, 10). Previous 24-hour movement behavior guidelines only considered sleep duration as an *exposure* on outcomes including physical activity and sedentary behavior. This was a gap in the international guideline development work to date, was considered important by UK stakeholders, and had emerged as a major influence on important health and developmental outcomes in recent years[6,19,20]. One of our sub-groups carried out the systematic review/evidence synthesis necessary to make recommendations based on the influence of physical activity and sedentary time on sleep outcomes (e.g. sleep duration, latency of sleep onset, sleep disturbance). The details of this work, with sleep as an outcome variable (rather than as an exposure variable), are beyond the scope of the current manuscript and so are reported elsewhere.[21]

Consensus around adoption and adaptation of the Canadian guideline in order to produce draft recommendations for the UK was achieved at two online meetings of the Expert Working Group in

April 2018. Draft recommendations and an accompanying draft technical report (explaining the basis of the draft recommendations) were shared with the stakeholders (**Table 1**, items 12-13) using an online consultation in June and July 2018, and face–to-face consultation in the form of the two Scientific Consensus meetings noted above.

RESULTS

There was consistent evidence that time spent in physical activity, sleep, and sedentary behavior was associated with a range of health and developmental outcomes in the Under 5s. A summary of this evidence base is provided in **Table 5.** The Expert Working Group made draft 24-hour movement behavior recommendations which were supported by a UK consensus and which were intended to become UK 24-hour movement guidelines. The *de novo development* part of the process produced draft recommendations on the avoidance of screens before bedtime. This was based on a combination of mechanistic studies on the impact of light exposure on sleep, and observational evidence that screen use before bedtime was associated with shorter sleep duration, more night wakening, and longer sleep latency (delayed onset of sleep) in Toddlers, and later bedtimes in Pre-schoolers[21]. Consultation responses suggested that advice to families around avoiding screens before bedtime would be valuable and appreciated, and there was some evidence that a period of around one hour before bedtime was optimal.

The UK Expert Working Group attempted to clarify exposure-outcome relationships in the evidence base, and this led to three main recommended adaptations of the Canadian and Australian guidelines:

1. It was possible for us to include a draft recommendation for active and outdoor play for Toddlers and Pre-Schoolers, since that was one of the specific physical activity exposures for which evidence was available (this type of physical activity was not referred to specifically in the Canadian or Australian guidelines). This type of physical activity has many benefits and few risks[22-24] and was valued highly by the Expert Working Group and by stakeholders.

2. A specific draft recommendation for moderate-to-vigorous-intensity physical activity (MVPA) was made, referred to as 'energetic play' in the Canadian and Australian guidelines. Inclusion of MVPA was possible because there was evidence with MVPA as the exposure in Pre-schoolers, and respondents in the second stage of the consultation welcomed the continuity between the MVPA recommendation for pre-schoolers and that for older children.

3. The Expert Working Group felt that the screen time guidance for Toddlers in the Canadian and Australian guidelines ('For those younger than two years screen time is not recommended') should be adapted rather than adopted, with a relaxation in the UK: 'screen time should be no more than one hour'. The rationale for this adaptation arose from limitations in the evidence around the precision of the 1 hour per day exposure (but good evidence that less screen time was better), the possibility that newer forms of sedentary screen time may be less harmful, and may be more beneficial than the more traditional forms (TV/DVD exposure) which dominated the evidence base, and the pragmatic consideration that recommending a limited amount of exposure may be seen as more helpful, and realistic, to modern families than recommending no exposure.

These draft recommendations derived from the GRADE ADOLOPMENT process are summarised in **Table 6.** In December 2018 the UK CMOs decided to not include the draft recommendations for time spent in sedentary behavior and time spent asleep, as well as screen time in relation to sleep outcomes, and so the final UK 2019 guidelines will be based on physical activity only, excluding the recommendations made by the Expert Working Group in relation to sedentary behavior and sleep. The new physical activity guidelines by age group are shown in **Table 7.**

DISCUSSION

The UK guideline on Physical Activity for the Early Years will be published in 2019. The new guideline is an advance on its predecessor in the UK as it includes more evidence based, quantitative recommendations (facilitating future surveillance), and has new guidance for both tummy time in infancy and MVPA in pre-schoolers. Subjective (parent-report) methods will be required for surveillance, at least initially, though the reliability and validity of existing methods are unclear[25]. Future surveillance of quantitative recommendations may require objective measurement.

The work described in this manuscript could have led to the first 'integrated' 24-hour movement behaviour guideline for Europe, rather than the physical activity guideline update which was published in 2019. Since the proposed 24-hour movement behavior guidelines were not adopted in the UK, it is worth a brief restatement of the rationale for the approach. First, the approach used to develop draft recommendations was evidence-based, following a rigorous, published, and transparent GRADE ADOLOPMENT process which produces robust guidelines at low cost and relatively quickly. The evidence base for sedentary behavior and sleep guidelines was not weaker than that for physical activity guidelines, and an opportunity for up-to-date, inexpensive, evidence-based guidelines for sedentary behavior and sleep in the UK was lost. Second, at numerous points in the stakeholder consultation processes in the UK a wide variety of individuals and organisations supported the 24-hour approach taken by the Expert Working Group. Evidence from the other countries with recently published 24-hour movement behavior guidelines for the early years supports the view that stakeholder (academic, policymaker, practitioner, family) acceptance of the 24-hour approach is high, and successful public health messaging of 24-hour movement behavior guidelines is a realistic objective[26,27]. Third, the approach would have been consistent with a number of other countries and the WHO guidelines which were published in 2019. International consistency was prioritised by the Expert Working Group, and supported by stakeholders during the consultations. Fourth, obesity prevention is high on the public policy agenda in the UK and the need for a shift in how infants, toddlers, and pre-schoolers spend their 24 hours was emphasised as central to obesity prevention in the WHO ECHO reports in 2016 and

2017[14,15]. Time spent in movement behaviors over 24 hours in the early years appears to be a major driver of the obesity epidemic[2,3,14,15,19] . Furthermore, shorter sleep duration pin the pre-school years predicts higher adiposity at school age[28,29]. Thus 24-hour movement guidelines would have supported new obesity strategies in the UK. Finally, an emerging body of evidence from Canada, Australia, and Belgium shows that many infants, toddlers, and pre-schoolers do not meet the new 24-hour movement behavior guidelines, and these behaviors may be socially patterned.[30-34] . As childhood obesity is highly socially patterned in the UK and social patterning is increasing[33], there is a need for 24-hour movement behavior guidelines in the UK in order to reduce social inequalities in health.

As the evidence base improves, guidelines will evolve, but guidelines are required now given the importance of the 24-hour movement behaviors in the early years to child health and development, and to the global public health and economic crisis caused by obesity and related NCDs[8,14,15]. Gaps in the evidence in the Under 5s should also be seen in the context of these behaviors later in childhood and adolescence: there is a more substantial evidence base on the benefits of adequate physical activity and sleep, and risks of some sedentary behaviors in school-age children [34-37]; levels of the behaviors in the pre-school period are closely related to later levels in school-aged children, and time spent sedentary increases steadily from the age of school entry. This contextual evidence complemented the evidence on the health and developmental impact of the time spent in 24-hour movement behaviors and provided impetus for recommendations for 24-hour movement guidelines for the Under 5s.

Some issues were beyond the scope of the Expert Working Group. In particular, the *content* of screen time was not considered. There were also some gaps and weaknesses in the evidence base. First, recommending precise amounts of all of the 24-hour movement behaviors was problematic. Precise amounts/durations were included in draft recommendations where possible, but expert opinion and other factors influenced these where appropriate (e.g. for consistency with international guidelines; need for a time-specific guideline so that surveillance can take place; the need to provide a foundation for

future guidelines; guideline updates/upgrades are implicit in guideline production, and in the absence of an initial 24-Hour Movement Guideline for the UK there may not be an update/upgrade). Second, one component of the 24-hour day not measured/recognised by recent studies is standing. Since standing was not measured in most studies, it does not appear in the literature and may be misclassified in accelerometry studies. This misclassification may obscure associations with health outcomes, and produce biases in estimates of the levels of these behaviors. For example, our unpublished data from postural monitoring of pre-school children suggests that they typically spend around 3 hours per 24 hours standing, but this behavior may be misclassified as light intensity physical activity by accelerometry. Finally, while TV and DVD were the main sources of screen time for the Under 5s, at least until recently[40] , there is a need for more evidence on the health and developmental impact of time spent using newer devices which became widely available more recently. Some forms of modern screen-based technology are potentially less harmful, and may bring greater benefits, than the kinds of sedentary behavior used to inform the new draft recommendations.

The GRADE ADOLOPMENT process facilitated a rapid and inexpensive revision of 24-hour movement guidelines from Canada and Australia to the UK. The work did not proceed to 24-hour movement guidelines as intended by the Expert Working Group, the UK academic community, and stakeholders. However, the evidence adaptation/ adoption processes undertaken clarified the complex associations between time spent in the 24-hour movement behaviors and important health and developmental outcomes, and the development process provided new insights into the impact of physical activity, sedentary behavior and screen time on sleep outcomes in early life.

ACKNOWLEDGEMENTS

We acknowledge the help of the WHO, both for funding an updated literature review and appraisal using GRADE methodology in February 2018, and for agreeing to share the literature search results with the Under 5s Expert Working Group. We also thank the many stakeholders who took part in the online and face-to-face consultation meetings. The work was undertaken with the support of The

Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement (DECIPHer), a UKCRC Public Health Research Centre of Excellence. Joint funding (MR/KO232331/1) from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical Research Council, the Welsh Government and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged. AM was supported by the UK Medical Research Council (grant number MC_UU_12017/14) and the Scottish Government Chief Scientist Office (grant number SPHSU14). KRH is supported by the Wellcome Trust (107337/Z/15/Z).

List of Tables

Table 1. Steps and timeline in the guideline development process using the GRADE-ADOLOPMENT approach[18]

Tasks		Timeline
1	Decision and stakeholder approval of the 24-hour movement behaviour approach	January 2018
2	Identification of appropriate source guidelines	14 February 2018
3	Feedback and agreement on WHO literature search strategy (PICOS), and 'grading' of importance of outcomes	1st March 2018
4	Review of GRADE Summary of Findings table from Canadian 2017 guideline	22 March 2018
5	Identification of appropriate source systematic reviews on sleep outcomes	22-26 March 2018
6	Assessment of need and decision for de novo systematic review on sleep outcomes	26 March 2018
7	Re-structuring the Canadian 2017 GRADE Summary of Findings table by outcome, movement behaviour and age group (infants, toddlers, pre-schoolers)	23 March – 13 June 2018
8	Inclusion of updated WHO systematic reviews to GRADE Summary of Findings table	29 March – 13 June 2018
9	Conducting de novo systematic review and evidence synthesis for the association of screen time, sedentary time and physical activity with sleep	17 April – 17 June 2018
10	Initial decision on adoption, adaptation and de novo creation of recommendations through consensus in April 2018	8 May 2018
11	Submission of progress report with a rationale as to whether and how the UK 2011 guidelines should change	15 May 2018

12	Final decision on adoption, adaptation and de novo creation of recommendations through Expert Group consensus	14-17 May 2018
13	Write-up of draft recommendations for scientific consensus meetings	7 June 2018
14	Add evidence from #10 to GRADE Summary of Findings table	17 June 2018
15	Revision of draft recommendations based on feedback at scientific consensus meeting	6 July – 5 September 2018
16	Submission of revised recommendations for UK-wide national consultation	6 September 2018
17	Revision of draft recommendations based on UK-wide national consultation	26 October 2018
18	Consideration of UK 24-Hour Movement Behaviour Guidelines for the Under 5s by the UK Health Departments (Chief Medical Officers)	30 November 2018

Table 2 Choice of Source Guidelines from Candidate Guidelines, Adapted from Okely et al[3]

Criterion	Canadian Guideline 2017	Australian Guideline 2017	US Physical Activity Guideline for Americans 2018
Published in last 5 years	**Yes**	**Yes**	**Not yet published as a guideline, just the evidence synthesis**
Followed GRADE	**Yes**	**Yes**	**No, but used an analogous process**
Addressed Clear Questions	**Yes**	**Yes**	**Yes, but not the same questions or range of questions required by the UK process**
Assessed Harms/Benefits	**Yes**	**Yes**	**No**
Assessed Using AGREE	**Yes**	**Yes**	**No**
Suitable for Updating	**Yes**	**Yes**	**Yes**
Access to evidence tables and summaries	**Yes**	**Yes**	**Yes**
Had risk of bias assessment	**Yes**	**Yes**	**Yes**

Were integrated (24 hours)	**Yes**	**Yes**	**yes**

Table 3 Basis of the Literature Searches and Evidence Syntheses: the PICOs (Population, Intervention/.Exposure, Comparator, Outcome)

Table 3A. PHYSICAL ACTIVITY

In children under 5 years of age what dose (i.e. volume, duration, frequency, pattern, type, and intensity) of physical activity, as measured by objective and subjective methods, is associated with favourable health indicators? (holistic definition of health applies)

Population: Apparently healthy children (i.e., general population, including overweight/obese) aged birth-59 months.

Intervention (Exposure):

- Objective (e.g. actigraphy, accelerometer) or subjective (e.g., proxy-report) measure of physical activity. Physical activity is defined as any bodily movement generated by skeletal muscles that results in energy expenditure above resting levels (>1.5 METs).
- "Prone position" or "tummy time" is considered an appropriate physical activity exposure in infants (up to 12 months of age).
- For experimental studies, interventions must target physical activity exclusively and not multiple health behaviours (e.g. both physical activity and diet) to provide clear evidence on the association between physical activity and the outcomes.

Comparator: Lower volumes, durations, frequencies, patterns, types and intensities of physical activity.

Outcomes (Health indicators):

Critical:

1. Adiposity
2. Motor development
3. Psychosocial health
4. Cognitive development
5. Fitness (cardiovascular and musculoskeletal)
6. Harms (i.e. injuries)

Important:

7. Skeletal health
8. Cardiometabolic health

Table 3B SEDENTARY BEHAVIOR

In children under 5 years of age what dose (duration, pattern, i.e. frequency and interruption), and type of sedentary behavior, as measured by objective and subjective methods, is associated with favourable health indicators?

Population: Apparently healthy children (i.e. general populations, including those with overweight/obesity) aged birth-59 months.

Intervention (Exposure):

- Objective (e.g. accelerometry, direct observation) or subjective (e.g., proxy-report) measure of sedentary behaviour time
- Sedentary behavior is defined as any waking behavior characterized by an energy expenditure of ≤1.5 METs while in a sitting or reclining posture

- For infants, sedentary behavior is operationally defined as any waking behavior characterized by low energy expenditure while restrained or when sedate.
- Time spent in the prone position ("tummy time"), and time spent being held without restraint are not considered sedentary exposures.
- For experimental studies, interventions must target sedentary behavior exclusively and not multiple health behaviours (e.g. both sedentary behavior and diet) to provide clear evidence on the association between sedentary behavior and the outcomes.

Comparator: Higher durations, patterns (frequency, interruptions), and types of sedentary behaviors.

Outcomes (Health indicators):

Critical:

1. Adiposity
2. Motor development
3. Psychosocial health
4. Cognitive development
5. Injuries or harms

Important:

6. Skeletal health
7. Cardiometabolic health
8. Fitness (cardiovascular and musculoskeletal)

Table 3C SLEEP

In children under 5 years of age what duration of sleep, as measured by objective and subjective methods, is associated with favourable health indicators?

(preamble should mention healthy sleep habits as well)

Population: Apparently healthy children (i.e. general populations, including those with overweight/obesity) aged birth-59 months.

Intervention (Exposure):

- Objective (e.g. polysomnography, actigraphy) or subjective (self-report, proxy-report) measures of sleep duration.
- Sleep duration defined as activity monitor (e.g. accelerometer) "non-wear" time is not considered a relevant exposure because this is not a valid measure of sleep.
- For experimental studies, interventions must target sleep exclusively and not multiple health behaviours (e.g. both sleep and diet) to provide clear evidence on the association between sleep and the outcomes.

Comparator: Lower sleep duration.

Outcomes (Health indicators):

Critical:

1. Emotional regulation
2. Cognitive development
3. Motor development
4. Growth
5. Adiposity

Important:

6. Cardiometabolic health
7. Physical activity and sedentary behaviours
8. Quality of life/well-being

9. Harms (i.e. injuries such as SIDS)

Table 3D INTEGRATED MOVEMENT BEHAVIORS

In children under 5 years of age what are the relationships between each of the following combinations of movement behaviors and health indicators?

- Sleep and sedentary behavior
- Sleep and PA
- Sedentary behavior and PA
- Sleep, sedentary behavior and PA

Population: Apparently healthy children (i.e. general population, including overweight/obese) aged birth-59 months.

Intervention (exposure): The combination of two or three movement behaviors (i.e. sleep, sedentary behavior, and physical activity) as defined previously

Comparator: Various levels and combinations of movement behaviors.

Outcomes (Health indicators):

Critical:

1. Adiposity
2. Motor development
3. Psychosocial health/emotional regulation
4. Cognitive development
5. Growth
6. Fitness (cardiovascular and musculoskeletal)

7. Harms(i.e. injuries)

Important:

8. Skeletal health
9. Cardiometabolic health

Table 4: Different Exposures by Type within the 24-Hour Movement Behavior Framework

Physical Activity	**Sedentary time**	**Sleep**
Total Physical Activity Light physical activity intensity Moderate physical activity intensity Moderate-to-vigorous physical activity intensity Vigorous physical activity intensity Active/Outdoor/Indoor/Exercise Play Prone position Outdoor PA (incl. bike riding, walking, active transport) Home/Leisure/extracurricular physical activity Aerobic physical activity Organised sport/sport participation Weight bearing activity	Screen time Evening screen time Device measured sedentary time	Sleep duration (total daily sleep) Night time sleep duration Sleep restriction Nap duration Increasing hours of sleep per bout Cortisol awakening response Sleep Trajectories

1 **Table 5. Summary of Evidence Quality, Quantity, and Generalisability**

Type of Evidence	Generalisability & Directions of Associations with Outcomes	Comments on Evidence
Physical Activity (PA)		
Experimental/quasi experimental studies: 14 RCT (n 4,199); 3 cross-over trials (n 182); 11 non randomised controlled trials (n 1,654) **Observational studies**: 9 case control (n 2,404); 16 longitudinal (n 18,354;)63 cross-sectional (n 77,452)	High generalisability to UK-evidence largely from high-income western countries **More PA is associated with improved**: **adiposity** (infants); **motor development** (infants, toddlers, pre-schoolers); **cognitive development** (infants, pre-schoolers); **fitness** (pre- schoolers); **bone/skeletal health** (pre-schoolers); **cardiometabolic health** (pre-schoolers).	Evidence for specific amounts/types of PA not clear /conclusive for all populations, but clear that 'more is better'. New evidence for benefits of higher intensity (MVPA) in pre-schoolers, and 'dose' of tummy-time in infants, and active/outdoor play.
Sedentary Behavior (SB)		
Experimental/quasi experimental studies: 2 RCT (n 482) **Observational studies:** 7 case-control (n 2,374); 34 longitudinal (n 78,100); 79 cross-sectional (n 167,946)	High generalisability to UK-as noted above for PA. **More SB is associated with:** higher **adiposity** (infants, toddlers, pre-schoolers); poorer **motor development** (toddlers), poorer **cognitive development** (infants,	Most of the evidence is on screen time (duration), mainly TV/DVD viewing. Evidence for specific amounts inconclusive,

	toddlers, pre-schoolers); poorer **psychosocial health** (pre-schoolers).	but clear that 'less is better'.
Sleep		
Experimental/quasi-experimental studies: 2 RCT/controlled trials (n 67); 3 cross-over trials (n 45) **Observational studies:** 3 case-control (n 810); 27 longitudinal (n 98,340); 48 cross-sectional (n 90,834)	High generalisability to UK-as noted above for PA. **Shorter sleep duration is associated with: higher adiposity** (pre-schoolers); **poorer emotional regulation** (infants, toddlers, pre-schoolers**); poorer cognitive development** (pre-schoolers).	Increased sleep duration within a currently recommended range seems to have little evidence of harm. Evidence largely on duration of sleep rather than related behaviours (e.g. sleep environment and routine). Evidence for specific amounts inconclusive

Table 6 The Draft UK 24-Hour Movement Behaviour Recommendations for the Under 5s, 2018

Infants (less than 1 year) For infants, a healthy 24 hours includes:

- Being physically active several times in a variety of ways, including interactive floor-based activity *e.g. crawling. For infants not yet mobile, this includes at least 30 minutes of tummy time*[Footnote1] *spread throughout the day while awake (and other movements such as reaching and grasping, pushing and pulling)*; more is better.
- Minimising the amount of time restrained (e.g., in a pram or high chair). Screen time is not recommended. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
- 14 to 17 hours (for those aged 0-3 months) or 12 to 15 hours (for those aged 4-11 months) of sleep, including naps.

Toddlers (1-2 years) For toddlers, a healthy 24 hours includes:

- At least 180 minutes spent in a variety of physical activities at any intensity, including active and outdoor play, spread throughout the day—more is better.
- Not being restrained (e.g., in a pram/buggy or high chair) or sitting for extended periods (except when sleeping). Sedentary screen time should be no more than 1 hour; less is better[Footnote2]. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
- 11 to 14 hours of good-quality sleep[Footnote3], including naps, with consistent bedtimes and wake-up times, avoiding use of screens for at least one hour before bed-time.

Pre-schoolers (3-4 years) For pre-schoolers, a healthy 24 hours includes:

- At least 180 minutes spent in a variety of physical activities spread throughout the day, including active and outdoor play,—more is better; the 180 minutes should include at least 60 minutes of moderate-vigorous intensity physical activity (MVPA).

- Not being restrained (e.g. in a buggy or car seat) or sitting for extended periods. Sedentary screen time should be no more than 1 hour; less is better[Footnote2]. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.

- 10 to 13 hours of good-quality sleep[Footonote3], which may include a nap, with consistent bedtimes and wake-up times, avoiding use of screens for at least one hour before bed-time.

Footnote 1. Tummy time may be unfamiliar to babies at first, but can be increased gradually-starting from a minute or two at a time-as the baby becomes used to it Babies should not sleep on their tummies.

Footnote 2 The historical evidence on screen time was largely from studies of the duration of screen time exposure to TV and DVD screens. These studies tend not to measure the type of content, nor the nature of the child's engagement with it. While it is generally assumed that the child is sedentary during screen time, some research suggests this is not always the case. There was a lack of evidence on the health and developmental impact of more recent screen-based technology, especially that which involves or requires interaction with other individuals (e.g. family members). The Expert Working Group felt that accompanied/interactive screen-time had less potential for harm and greater potential for benefit than solitary or sedentary screen time

F**ootnote 3** Good quality sleep is not excessively restless or broken by long periods of wake. Note children normally have brief wakings during the night but learn to settle themselves back to sleep within a few minutes.

Table 7 The UK 2019 Physical Activity Guidelines for the Under 5s

Infants. Being physically active several times in a variety of ways, including interactive floor-based activity e.g. crawling. For infants not yet mobile, this includes at least 30 minutes of tummy time[Footnote] spread throughout the day while awake (and other movements such as reaching and grasping, pushing and pulling); more is better.

Toddlers. At least 180 minutes spent in a variety of physical activities at any intensity, including active and outdoor play, spread throughout the day—more is better.

Pre-Schoolers. At least 180 minutes spent in a variety of physical activities spread throughout the day, including active and outdoor play,—more is better; the 180 minutes should include at least 60 minutes of moderate-vigorous intensity physical activity (MVPA).

Footnote. Tummy time may be unfamiliar to babies at first, but can be increased gradually-starting from a minute or two at a time-as the baby becomes used to it Babies should not sleep on their tummies.

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